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**BIOLOGICAL ASSESSMENTS FOR THE
LOW ENERGY DEMONSTRATION ACCELERATOR,
1996 AND 1997**

by Saul Cross

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TABLE OF CONTENTS

ABSTRACT	1
I. ENVIRONMENTAL SETTING	2
1.1 General Setting and Climate	2
1.2 Sandia Canyon	5
1.3 Description of Area to be Affected by LEDA Discharges	12
II. PROJECT DESCRIPTION	14
2.1 The LEDA Project	14
2.2 Annual Biological Assessments	17
III. SOILS	18
3.1 Erosion Control	20
3.2 Hydric Soils	20
3.3 Soils within the LEDA Drainage	23
IV. WATER QUALITY	25
4.1 Sandia Canyon and Water Quality Standards	25
4.2 NPDES Sampling	26
V. VEGETATION	28
5.1 Vegetation of New Mexico	28
5.2 Vegetation of LANL	28
5.3 Vegetation of the Project Area	29
5.3.1 1996 Vegetation Survey Results	31
5.3.2 1997 Vegetation Survey Results	34
5.3.3 Combined Vegetation Survey Results	37
VI. WILDLIFE	38
6.1 Wildlife of LANL	38
6.1.1 Invertebrates	38
6.1.2 Fish	38
6.1.3 Reptiles and Amphibians	39

6.1.4 Birds	39
6.1.5 Mammals	39
6.2 Wildlife of the Project Area	40
6.2.1 Birds	41
6.2.2 Reptiles and Amphibians	42
6.2.3 Large Mammals	45
VII. THREATENED AND ENDANGERED SPECIES	45
VIII. BIOLOGICAL BEST MANAGEMENT PRACTICES	48
IX. CONCLUSIONS	49
X. ACKNOWLEDGMENTS	51
XI. GLOSSARY OF ACRONYMS AND TECHNICAL TERMS	53
XII. CITATIONS	57

LIST OF FIGURES

Fig. 1. Location of Los Alamos National Laboratory, New Mexico.	3
Fig. 2. Location of TA-53 with respect to Laboratory TAs and surrounding lands.	4
Fig. 3. 1996 monthly precipitation totals for the middle Sandia Canyon area.	7
Fig. 4. 1997 monthly precipitation totals for the middle Sandia Canyon area.	8
Fig. 5. National Wetland Inventory map for Sandia Canyon.	10
Fig. 6. Biological Monitoring Area for the LEDA Project.	19

LIST OF TABLES

Table 1. Soil Particle Classifications	20
Table 2. Soil Pit Locations and Soil Characteristics.	23
Table 3. NPDES Maximums for Outfall 03A113.	27

Table 4. Dominant Understory Plants in the LEDA Drainage, Transects 1 and 2, 1996.	32
Table 5. Dominant Understory Plants in the LEDA Drainage, Transects 3 and 4, 1996.	33
Table 6. Dominant Understory Plants in the LEDA Drainage, Transects 1 and 2, 1997.	35
Table 7. Dominant Understory Plants in the LEDA Drainage, Transects 3 and 4, 1997.	36
Table 8. Reptiles and Amphibians Captured in Middle Sandia Canyon during 1996.	43
Table 9. Reptiles and Amphibians Captured in Middle Sandia Canyon during 1997.	44
Table 10. USFWS T&E Species List for Los Alamos County, March 1996.	47

APPENDICES

APPENDIX A. Plant Species within 1996 Vegetation Transects in Mid-Sandia Canyon.	45
APPENDIX B. Bird Species Found in 1996 Mid-Sandia Canyon Bird Transect.	47
APPENDIX C. Reptiles and Amphibians Species Captured during the 1996 Trapping Season in Mid-Sandia Canyon.	49

**BIOLOGICAL ASSESSMENTS FOR THE
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ABSTRACT

The Department of Energy (DOE) plans to build, install, and operate a Low Energy Demonstration Accelerator (LEDA) in Technical Area 53 of the Los Alamos National Laboratory (LANL). LEDA will demonstrate the accelerator technology necessary to produce tritium, but is not designed to produce tritium at LANL. USFWS reviewers of the Biological Assessment prepared for LEDA insisted that the main drainage be monitored to measure and document changes to vegetation, soils, wildlife, and habitats due to LEDA effluent discharges. The Biology Team of ESH-20 (LANL's Ecology Group) has performed these monitoring activities during 1996 and 1997 to document baseline conditions before LEDA released significant effluent discharges. Quarterly monitoring of the outfall which will discharge LEDA blowdown effluent had one exceedance of permitted parameters, a high chlorine discharge that was quickly remedied. Samples from 12 soil pits in the drainage area contained no hydric indicators, such as organic matter in the upper layers, streaking, organic pans, and oxidized rhizospheres. Vegetation transects in the meadows that LEDA discharges will flow through contained 44 species of herbaceous plants, all upland taxa. Surveys of resident birds, reptiles, and amphibians documented a fauna typical of local dry canyons. No threatened or endangered species inhabit the project area, but increased effluent releases may make the area more attractive to many wildlife species, an endangered raptor, and several other species of concern. Biological best management practices especially designed for LEDA are discussed, including protection of floodplains, erosion control measures, hazards posed by increased usage of the area by deer and elk, and revegetation of disturbed areas.

Author's note: This report updates and expands upon a previous report entitled "Biological Assessments for the Low Energy Demonstration Accelerator, 1996" by Saul Cross (Cross 1996a).

I. ENVIRONMENTAL SETTING

1.1 General Setting and Climate

The Low Energy Demonstration Accelerator (LEDA) will be sited within the boundaries of the Los Alamos National Laboratory (LANL). The 111-km² (43-mi²) Laboratory site is located in north-central New Mexico on the Pajarito Plateau, approximately 120 km (80 mi) north of Albuquerque and 40 km (25 mi) west of Santa Fe (Fig. 1). In the LANL region, the eastern edge of the Pajarito Plateau descends to the Rio Grande in White Rock Canyon. The Rio Grande flows in a southwesterly direction along the easternmost boundary of LANL.

Most LANL industrial developments are confined to the mesa tops, which range in elevation from a maximum of 2,400 m (7,800 ft) above sea level (asl) along the western boundary to about 1,900 m (6,200 ft) asl at their eastern terminus above the Rio Grande. The canyons within LANL boundaries can be as deep as 300 m (1,000 ft) below the mesa top. LANL is divided into Technical Areas (TAs) that contain administrative and support function buildings, experimental and research areas, waste disposal areas, roads, and utility corridors (Fig. 2). However, these components occupy only a small part of LANL's total land area, and the remainder is reserved as buffer zones and potential sites for future development (EPG 1996).

Most of the mesas in the Los Alamos area are formed from Bandelier Tuff, which includes ash fall, ash fall pumice, and rhyolite tuff. The tuff, ranging from nonwelded to welded, is more than 300 m (1,000 ft) thick in the western part of the Plateau and thins to about 80 m (260 ft) eastward above the Rio Grande. It was deposited as a result of major

Fig. 1. Location of Los Alamos National Laboratory, New Mexico.

Fig. 2. Location of TA-53 with respect to Laboratory TAs and surrounding lands.

volcanic eruptions in the Jemez Mountains approximately 1,200,000–1,600,000 years ago. The tuff overlaps onto the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains. In the central and eastern edge along the Rio Grande, the tuff is underlain by the conglomerate of the Puye Formation. Chino Mesa basalts intermix with the conglomerate along the river. These formations overlay the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 1,000 m (3,300 ft) thick (EPG 1996).

LANL has a semiarid, temperate mountain climate. Summer temperatures range from 21°C to 31°C (70°F to 88°F), during the daytime, to 10°C to 15°C (50°F to 59°F) during the nighttime. Temperatures occasionally will break 32°C (90°F). The highest temperature ever recorded in Los Alamos is 35°C (95°F).

Winter temperatures range from -1°C to 10°C (30°F to 50°F), during the daytime, to -9°C to -4°C (15°F to 25°F) during the nighttime. The lowest temperature ever recorded in Los Alamos is -28°C (-18°F). Winter is not particularly windy, so extreme wind chills are uncommon in Los Alamos (EPG 1996).

The average annual precipitation is 48 cm (18.7 in.), and the first five years of the 1990s are considered to be normal rainfall years. Approximately 48% of the annual precipitation normally falls during July–September rains. Runoff from late-summer thundershowers flows through the various canyons, supplementing ground water in the shallow alluvium. Winter precipitation falls primarily as snow with accumulations of about 150 cm (59 in.) (EPG 1996).

1.2 Sandia Canyon

Sandia Canyon has three reaches: an upper reach consisting of a cattail (*Typha*

latifolia) marsh and a narrow channel with a coniferous overstory, a middle reach consisting of a usually-dry flat floodplain with a variable overstory, and a lower reach with a coniferous overstory. The first two reaches occur on LANL property, and LEDA effluent releases will eventually be discharged into the middle canyon reach. The lowest reach occurs primarily on lands belonging to the Pueblo of San Ildefonso and includes the confluence of Sandia Canyon with the Rio Grande.

The head of Sandia Canyon is near the University House in TA-3, and the canyon extends southeastward from this point to the Rio Grande. The drainage basin occupies approximately 13.5 km² (5.6 mi²), with the initial 7.5 km (4.7 mi) of the canyon occurring on LANL property. Industrial effluents from LANL activities maintain a year-round stream flow in upper Sandia Canyon. The lower canyon has seasonal flows, and stream water reaches the Rio Grande only a few days each year due to storm events and snowmelt. Monthly 1996 and 1997 precipitation totals from the nearest meteorological station (located within TA-53) are shown in Figs. 3 and 4.

The National Wetlands Inventory (NWI) conducted by the U.S. Fish and Wildlife Service (USFWS) identified three types of wetlands or water systems within Sandia Canyon (Cowardin et al. 1979). These determinations were made primarily by stereoscopic analysis of high altitude aerial photographs and were not field checked. The aerial photographs typically reflect conditions during the specific year and season when they were taken. Federal, State, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. According to the NWI, the upper reach in TA-3 is a "persistent, artificially flooded, palustrine wetland." "Intermittent, temporarily flooded, riverine stream beds"

Fig. 3. 1996 monthly precipitation totals for the middle Sandia Canyon area.

Fig. 4. 1997 monthly precipitation totals for the middle Sandia Canyon area.

occur within the canyon both upstream and downstream from the project area. The confluence of Sandia Canyon with the Rio Grande has a "permanently flooded, lower perennial riverine wetlands with an unconsolidated bottom." The NWI map of Sandia Canyon is shown in Fig. 5.

The Biology Team of LANL's Ecology Group (ESH-20) has studied upper Sandia Canyon for the past several years. The team monitored aquatic macroinvertebrates, habitat suitability, and water quality parameters (pH, water temperature, dissolved oxygen, and conductivity) in the upper canyon area monthly from 1992 through 1996. Annual status reports (Bennett 1994; Cross 1994, 1995, 1996b) document conditions found within and below a cattail-dominated marsh, the largest wetlands on LANL property.

The Sandia Wetlands occurs downgradient from TA-3 and has received effluent discharges from LANL operations since the early 1950s. This wide expanse of cattails is surrounded by Gambel's oak (*Quercus gambelii*) and several species of coniferous trees. A perennial stream flow is currently maintained primarily by discharges from cooling towers below the TA-3 power plant, recirculated water from the Sanitary Waste Systems Consolidation (SWSC) plant, and storm water diversions from TA-3 roads, buildings, and parking lots. A large culvert underneath a demolition landfill empties water from the TA-3 power plant, diverted storm water, and several low-volume LANL outfalls into the head of the canyon. Approximately 40 m (125 ft) from the culvert, SWCS Outfall 13S releases excess reuse water on a southern hillside, and much of this discharge flows into the stream channel.

Typical flows range between 40 to 60 gpm through the culvert and 100 to 150 gpm through Outfall 13S, although storm events tremendously increase these volumes.

Fig. 5. National Wetland Inventory map for Sandia Canyon.

Waters from both points of discharge commingle in the channel that has cut through soft sediments near the center of the canyon. More accurate and continuous measurements of water flows is required before the magnitude of storm events in the upper canyon area can be quantified.

Downstream from the cattail marsh, the stream passes through an approximately 3.0-km (1.9-mi) stretch of densely shaded narrow canyon. The overstory consists primarily of Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), and white fir (*Abies concolor*). Several riparian trees and shrubs grow along the stream bank, including coyote willow (*Salix exigua*), water birch (*Betula occidentalis*), and Rocky Mountain maple (*Acer glabrum*).

The stream emerges from the shaded canyon in the TA-53 area. Here, the drainage is contained within a deep ravine bordered by the precipitous roadbed of East Jemez Road to the north. The southern edge of the stream is a steep hillside densely forested by Douglas-fir, ponderosa pine, and small Gambel oak trees. The streambed substrate consists primarily of cobbles, gravels, and fine sediments eroded from upstream areas.

The narrow ravine extends for approximately 1.6 km (1.0 mi) before the drainage enters a large meadow extending along both sides of East Jemez Road in the middle canyon section. Discharges from the LEDA outfall will enter the canyon near the head of this meadow, where the flat grassy area is approximately 145 m (480 ft) wide with the road running through its center. Tall (21 m or 70 ft) sheer tuff cliffs ring the northern edge of the meadow, while the southern edge is more gradual and is well vegetated with coniferous trees. The upper meadow contains only a few scattered trees, but the overstory is fairly thick downstream, consisting of one-seed juniper (*Juniperus monosperma*), piñon

pine (*Pinus edulis*), and ponderosa pine trees with a shrub layer of skunkbush (*Rhus trilobata*) and small Gambel oak. The drainage meanders through this fairly flat section for approximately 4 km (2.5 mi) until it crosses State Route 4 and enters lands belonging to the Pueblo of San Ildefonso in the lower canyon section.

1.3 Description of Area to be Affected by LEDA Discharges

Cooling water from LEDA operations will be discharged at Outfall 03A113 behind buildings 53-293 and 53-294. The Clean Water Act established the National Pollutant Discharge Elimination System (NPDES) as a means to assess point-source effluent discharges of the nation's waters, and Outfall 03A113 is permitted and monitored under the NPDES regulations. Effluent from LEDA will be discharged at the mesa's edge and onto a steep hillside on Sandia Canyon's northern edge. The area immediately to the east and partially above the outfall is unvegetated and covered with loose fill from road construction. This material covers a steep 12-m (40-ft) -high slope, is eroding, and is a source of sediments to the lower portion of the outfall drainage. The point of discharge is a 0.8-m (2.5-ft) -wide culvert near an industrial area of buildings, parking lots, and paved roads. This outfall has previously discharged effluents from other TA-53 operations, and a second culvert located 1.5 m (5 ft) to the west discharges into the same drainage.

Effluent from Outfall 03A113 flows southward onto exposed tuff which has been mechanically scooped out to form a short channel that is 0.8-m (2.5-ft) -deep and 0.9-m (3-ft)- wide. The upper section is fairly level for about 6 m (20 ft), after which the drainage spreads out as it descends a steep section of tuff for another 7.5 m (25 ft). The drainage then levels out for another 30 m (100 ft) until it drops off the sheer 18-m (60-ft)

tuff mesa edge into the northern side of middle Sandia Canyon, where a plunge pool has formed.

The lower outfall drainage initially has a thick overstory of small Gambel oak, skunkbush, and scattered ponderosa pine and is well shaded by the overstory and surrounding cliffs. The drainage meanders for approximately 85 m (240 ft) until it enters a large grassy meadow to the north of East Jemez Road. This section of the channel is as much as 1.2 m (4 ft) deep and 1.8 m (6 ft) wide with a substrate primarily of sand with some cobbles. In this stretch, the channel has cut through the loose and erodable alluvium exposing unvegetated banks. The drainage abruptly turns eastward, paralleling the north of East Jemez Road, and its route becomes less certain. Sandy deposits mark the drainage for another 50 m (165 ft) until it disappears in the tall grasses and forbs. It is apparent that past flows have seldom carried materials beyond this point. However, LEDA discharges may eventually reach the main channel of Sandia Canyon, which lies to the south of East Jemez Road.

Increased discharges may flow an additional 45 m (150 ft) through the northern section of the meadow and pass under East Jemez Road through an existing culvert. Once on the south side of East Jemez Road, the effluent would enter the main drainage in Sandia Canyon, where the canyon is approximately 115 m (380 ft) wide. The channel is 0.15–0.3 m (0.5–1.0 ft) deep and 2.5–4.6 m (8–15 ft) wide with a substrate of sands and gravels. These fine sediments and the channel's meandering pattern are characteristic of slow flows. The drainage continues along the fairly level floodplain for approximately 3.5 km (2.2 mi) until it passes underneath State Route 4 and briefly onto property of Bandelier National Monument. Most of lower Sandia Canyon occurs on Pueblo of San Ildefonso

lands. The canyon ultimately joins with the Rio Grande approximately 5 km (3 mi) east of LANL property.

II. PROJECT DESCRIPTION

2.1 The LEDA Project

The Department of Energy (DOE) plans to build, install, and operate LEDA in building MPF-365 at TA-53. LEDA will demonstrate the technology of the low-energy (40 MeV or less) front end of the high-energy (1000 MeV or more) accelerator that would be necessary to produce tritium. LEDA will be located at Los Alamos, but the final Accelerator Production of Tritium plant will be located at Savannah River, South Carolina.

The LEDA project is not intended to produce tritium or other radioactive materials. The proton beam will not pass through water, but neutrons produced when protons hit the beam stop may generate trace amounts of tritium when they strike the beam stop cooling water. This potentially activated water will be contained in a closed loop. This closed loop will be isolated from the cooling-tower loop by an intermediate heat-exchanger loop. The radioactive beam stop cooling loop is thus doubly-isolated from the cooling-tower loop to prevent release into the environment. The LEDA beam stop will be designed to minimize tritium production whereas the final accelerator production of tritium plant beam stop will be designed to maximize tritium production. A more complete description of the project is included in the Environmental Assessment prepared for the LEDA project (ESH-20 1996).

The purpose of LEDA is for research and development of accelerator technology only. The accelerator was initially planned to be staged in five steps, which would be developed over seven years:

- Stage 1 is the injector only, with a final beam energy of 0.075 MeV and a beam current of 110 mA.
- Stage 2 includes the injector plus a radio-frequency quadrupole (RFQ) accelerator having a final beam energy of 7 MeV and a beam current of 100 mA.
- Stage 3 includes the injector, RFQ, and a section of a coupled-cavity drift tube linear accelerator (CCDTL) with a final beam energy of 20 MeV and a beam current of 100 mA.
- Stage 4 adds another section of a CCDTL accelerator to bring the 20 MeV beam up to 40 MeV.
- Stage 5 adds a second injector, RFQ, and 20-MeV CCDTL to bring the beam current up to 200 mA. Another CCDTL module may be added to produce a final beam energy of 30 MeV.

The original schedule has been changed, and the project has been scaled back. A Safety Analysis Document (SAD) written for LEDA only covers activities through Stage 3. Stage 3 is also limited by reducing the proton beam from 20 MeV to approximately 12 MeV. As written, the SAD limits the project to the first 3 stages, but the document could be rewritten to include Stage 4. Stage 5 is no longer considered in the LEDA project at LANL (DOE 1997). The schedule (which is tentative and subject to receiving necessary

funding) calls for the commencement of installation for Stage 1 in October 1996, Stage 2 in July 1997, and Stage 3 in July 1998.

The heat generated by the LEDA beam stop will be released through water cooling towers. The cooling capacity of the present MPF-365 cooling tower is 2.9 MW, which is sufficient for Stage 1. Estimations of required cooling needed for subsequent stages are 9.5 MW for Stage 2, and 12 MW for Stage 3. This may require the installation of larger cooling towers adjacent to building MPF-365 to sufficiently increase the cooling capacity.

Increased cooling tower capacity will increase water discharge (blowdown) through Outfall 03A-113. This outfall is currently permitted, as required by the NPDES, and is monitored by ESH-18 (LANL's Water Quality and Hydrology Group). The quantities of water to be discharged into Outfall 03A-113 are 44,900 gal./day during Stage 2 and 64,800 gal./day during Stage 3. These are maximized average daily discharges, calculated by dividing the projected amount of water to be discharged into the outfall each year (17,000,000 gal. for Stage 2 and 24,000,000 gal. for Stage 3) by 365 days. However, the project is not realistically expected to operate 365 days a year. Initially, it was thought that the project would release significantly larger quantities of water during later stages, and Stages 4 and 5 releases were estimated at 107,000 gal./day (39,000,000 gal./yr.).

Elimination of Stages 4 and 5 from LEDA greatly reduce the project's potential for impacts to the surrounding landscape. A land disturbance of greater than 5 acres requires that a Storm Water Pollution Prevention Plan be written. At that point, it is clear that any increase in power demand for Stage 3 would disturb less than 5 acres to accommodate any modification of the utility power corridor to TA-53. The existing

building electrical power at Building MPF-365 is believed to be adequate for the scaled back project, and will probably not require expansion and modification (DOE 1997).

2.2 Biological Assessments

The proposed LEDA project required a National Environmental Policy Act (NEPA) review before modification of existing structures and construction could proceed. NEPA guidelines would not allow a categorical exclusion of LEDA's planned activities, and an environmental assessment was performed to determine how the project would affect environmental and human health. Upon receipt of the environmental assessment, DOE issued a Finding of No Significant Impact (FONSI). The FONSI concluded that the proposed action's environmental effects would be minimal and approved the commencement of LEDA operations. Areas of concern were to be addressed through a Mitigated Action Plan (MAP), which would report the status of all LEDA mitigation activities in a series of annual reports (DOE 1996). The first annual report was written for calendar year 1996 and was issued in March 1997 (DOE 1997).

The USFWS reviews major federal construction projects for potential effects on threatened and endangered (T&E) species, floodplains and wetlands, and other sensitive habitats. A Biological Assessment (Cross 1996c) was prepared for the LEDA project and submitted to the USFWS office in Albuquerque for review. It was impossible to state with certainty what effect LEDA effluent discharges would have on Sandia Canyon and whether or not a wetland area would be created. USFWS reviewers insisted that the main drainage be monitored to measure and document changes to vegetation, soils, wildlife, and habitats due to LEDA discharges. Therefore, the following section was added to the

assessment to address these concerns:

“...biologists will monitor the lower drainage areas for changes in flora, fauna, and soils. We will survey permanent vegetation transects within Sandia Canyon at least annually. Pitfall traps will be installed and checked daily during the sampling season for reptiles and amphibians. Birds will be censused during the summer when resident populations and diversity are highest. Soil cores will be removed with a hand auger and examined for the presence of organic material content, streaking, and organic pans.”

The Biology Team of LANL's ESH-20 completed all aspects of the first two year's monitoring program during 1996 and 1997, and the results and discussion of these studies form the basis of this report. The biological monitoring area for the LEDA project is shown in Fig. 6.

The information collected prior to large effluent releases will be used as baseline data to compare with subsequent data collected during active discharges and after project termination. A wetlands is defined by hydrology, vegetation, and soils; and all three of these parameters will be measured. If significant effluent discharges are released into Sandia Canyon, a study of resident aquatic invertebrates will be initiated in accordance with established protocols. Water quality parameters of pH, water temperature, dissolved oxygen, and conductivity will be measured simultaneously with invertebrate collection. These data and their analyses will be included in future annual reports.

III. SOILS

Soils consist of unconsolidated natural material that supports, or is capable of supporting, plant life. The mineral portion and organic matter in a soil are influenced by

Fig. 6. Biological Monitoring Area for the LEDA Project.

many interacting environmental factors. The mineral portion consists of soil particles or "separates" that are defined according to their size (Table 1). A soil's texture is determined by the relative proportions of soil particles present, and most soils contain a mixture of particles. Mineral soils have relatively small amounts of organic matter, while histosols are composed primarily of organic matter.

Table 1. Soil Particle Classifications.

Soil Particle	Size (mm)	Size (in.)
Gravel	> 2.00	> 0.07874
Sand	0.05–2.00	0.01969–0.07874
Silt	0.002–0.05	0.00078–0.01969
Clay	< 0.002	< 0.00078

3.1 Erosion Control

Potential erosion problems in the outfall drainage due to LEDA effluent discharges will be monitored. The LEDA MAP states, "The cooling tower waste water released through Outfall 03A113 will be monitored quarterly by ESH-18 personnel [LANL's Water Quality and Hydrology Group] to ensure the discharge meets the requirements of LANL's NPDES permit. At the same time, the drainage channel of the outfall will also be monitored for erosion effects. If needed over the course of the project development, appropriate erosion controls will be implemented by the LEDA project management employing Best Management Practices. Erosion controls could consist of such Best Management Practices as the installation of a spill pad with velocity breakers" (DOE 1996).

3.2 Hydric Soils

Soils, hydrology, and vegetation are the three components of a wetlands as defined

by the U. S. Corps of Engineers and the U. S. Environmental Protection Agency. Soil analysis allows long-term interpretation of local conditions, as opposed to plants and hydrology, which can change relatively rapidly. Soils in along the drainages are thus not expected to change drastically due to increased LEDA effluent discharges. Soils are analyzed to assess long-standing and baseline conditions in and near the drainages. If water inputs do increase significantly, a corresponding increase in organic material in the drainage soils is expected to be one of the first noticeable changes.

Wetlands typically have hydric soils. A hydric soil forms under conditions of saturation, flooding, or ponding sufficient to develop anaerobic conditions in the upper layers. Although all soil-forming factors (climate, parent material, relief, organisms, and time) affect the characteristics of a hydric soil, the overriding influence is the hydrological regime.

The unique characteristics of hydric soils result from the influence of periodic or permanent inundation or soil saturation for sufficient duration to effect anaerobic conditions. Prolonged anaerobic soil conditions lead to a reducing environment, resulting in chemical reduction of some soil components. Such reduction ultimately leads to the development of soil colors and other physical characteristics indicative of hydric soils (WTI 1995).

Most soils in the mid-Sandia Canyon drainage are composed primarily of sand. If hydric soils did develop in this area, they would be hydric mineral soils containing low amounts of organic matter. In most sandy soils, soil color should not be used as a wetlands indicator because the color of these soils only reflects the color of the parent

material. However, three additional soil features are used as indicators of sandy hydric soils (WTI 1995):

- **High organic matter content in the upper layers.** Organic matter tends to accumulate in the surface layers of sandy soils that are inundated or saturated to the surface for a significant portion of the growing season. Prolonged inundation or saturation creates anaerobic conditions that greatly inhibit oxidation of organic matter and promote reducing conditions. Such reduction requires the reduction of iron rather than simply the depletion of free oxygen (Vepraskas 1995).
- **Streaking of subsurface layers by organic matter.** Organic matter is moved downward through sand as the water table fluctuates. This often occurs more rapidly and to a greater degree in some vertical sections of a sandy soil containing high content of organic matter than in others. Thus, the sandy soil appears vertically streaked with darker areas.
- **Organic pans.** As organic matter is moved downward through sandy soils, it tends to accumulate at the point representing the most commonly occurring depth to the water table. This organic matter tends to become slightly cemented with aluminum, forming a thin layer of hardened soil. These horizontal accumulations occur at depths of 30–75 cm (12–30 in.) below the surface.

Living plant roots carry free oxygen into the soil. This oxygen is reduced in anaerobic soils, creating visible reddish rhizospheres surrounding the plant's fine roots. Such rhizospheres thus provide an additional indicator of saturated conditions, if live vegetation occurs within the sampling area.

3.3 Soils within the LEDA Drainage

The Biology Team dug soil pits down-gradient from Outfall 03A113, the site of LEDA effluent discharges. Pits NH-1, NH-4, NH-5, SH-2, SH-4, and SH-6 were dug in December 1996; and pits NH-2, NH-3, NH-6, SH-1, SH-3, and SH-5 were dug in September 1997. The 6 soil pits within and beside the outfall drainage were designated with an "N" because they occur to the north of East Jemez Road. The 6 pits dug within the main mid-Sandia Canyon were designated with an "S" because they occur to the south of the road.

Hydric characteristics can be destroyed in a main channel by repeated flooding, and pits were excavated in the channel, in sand bars, and in bordering vegetation (Table 2) to sample a number of representative areas. Each pit was 45 cm (18 in.) deep and steep-sided to allow accurate determination of relevant soil characteristics. Soils from different levels in each pit were sampled and analyzed. All soils were moistened and manipulated by kneading to determine soil types.

Table 2. Soil Pit Locations and Soil Characteristics.

Soil Pit #	Location	Soil Characteristics
NH-1	within lower outfall drainage at sharp bend to the east, unvegetated.	surface of sand; no roots; virtually no organic matter in the upper layers; upper 14 cm (5.5 in.) of loose sand; lower layer a sandy loam.
NH-2	6 m (20 ft) east of NH-1; within the 1.2-m (4-ft) wide drainage; a little scattered vegetation of cockle bur, white sweet clover, and mullein.	surface of sand and small gravel; no roots; virtually no organic matter; upper 18 cm (7 in.) of coarse sand; lower layer a sandy loam.
NH-3	20 m (65 ft) east of NH-1; on sandbar along south-side of drainage; some vegetation of mullein, false tarragon; white prairie clover, white sweet clover, and grasses.	surface of sand, gravel, and occasional pumice chunks; several small roots, but no oxidized rhizospheres; sand at all depths.

Soil Pit #	Location	Soil Characteristics
NH-4	22 m (70 ft) east of NH-1; on a sand bar with scattered cocklebur, false tarragon, and aster.	surface of sands and small gravels with occasional cobbles; roots but no oxidized rhizospheres; little organic matter near surface; nearly pure sand at all depths.
NH-5	26 m (85 ft) east of NH-2, within area vegetated with blue grama and false tarragon.	surface covered with herbaceous vegetation; many roots but no oxidized rhizospheres; some organic matter in the upper layers; sand noticeable only in the upper 4 cm (1.5 in.); some light streaking; lower levels a silty clay loam.
NH-6	40 m (130 ft) east of NH-1; in well-vegetated area south of drainage; plants include false tarragon, nodding brome, blue grama.	surface covered with vegetation; many roots, but no oxidized rhizospheres; soil more compacted than at NH-2 or NH-3; first 16.5 cm (6.5 in.) a silt loam; lower layer a sandy loam.
SH-1	15 m (50 ft) east of culvert under East Jemez Road; in center of 6-m (20-ft) wide drainage; unvegetated.	sand and gravel on surface; a few roots present, but very little organic material; coarse sand throughout; some black horizontal streaks in upper 18 cm (7 in.) similar to those on surface of drainage.
SH-2	30 m (100 ft) east of culvert; in center of main drainage; unvegetated.	black horizontal bands in upper 20 cm (8 in.) similar to surface splotches in drainage; virtually no organic matter in the upper layers; nearly pure sand at all depths.
SH-3	46 m (150 ft) east of culvert; on alluvial bench 3.5 m (10 ft) north of channel; surface sparsely vegetated with false tarragon, white sweet clover, wild chrysanthemum.	little sand on surface; surface cracking into shallow sections when dug; many intact roots, but no oxidized rhizospheres; upper 16.5 cm (6.5 in.) a loamy sand; lower layer a sand.
SH-4	58 m (190 ft) east of culvert; north of main channel but in area of alluvial deposition; within area vegetated with sand dropseed and rabbitbrush.	surface with plants, sand, and small gravel; roots but no oxidized rhizospheres; slight organic matter in the upper layers; nearly pure sand at all depths.
SH-5	73 m (240 ft) east of culvert; on unvegetated sandbar to south of drainage.	surface of sand with some gravel deposited nearby; no roots present; coarse sand at all depths.
SH-6	85 m (280 ft) east of SH-3; on a low sand bar vegetated with rabbitbrush, aster, and cocklebur.	surface with plants, sand, and small gravel; roots but no oxidized rhizospheres; slight organic matter in the upper layers; nearly pure sand at all depths.

Seven of the 12 soil pits had a soil type of sand (sand forming more than 85% of the soils particles) at all depths. Three more pits had sand as the soil type in the upper or lower portion. All other soil types found were varieties of loam, a broad class of soils containing a mixture of soil particle classes. The most common type of loam encountered was sandy loam, which contains at least 50% sand. The most developed soil types occurred in the areas with the greatest vegetation cover.

All soils in the excavated pits were checked for organic matter in the upper layers, streaking, organic pans, and oxidized rhizospheres (where plant roots were present). None of these hydric soil indicators were found in any of the soils. Upper layers of SH-1 and SH-2 soils had dark horizontal bands, but these were not the vertical streaks indicative of a hydric soil. (Much of the surface of the mid-Sandia Canyon drainage had similar deposits, which are believed to be accumulations of silts and clays from recent flooding.) Apparently, the periods of saturation in the lower Outfall 03A113 and mid-Sandia Canyon drainages are too short to produce hydric soils.

IV. WATER QUALITY

4.1 Sandia Canyon and Water Quality Standards

ESH-18 installed a water-gaging station in mid-Sandia Canyon near the eastern LANL boundary. The drainage area above the station is 6.53 km² (2.52 mi²), and the flow is partially regulated by the Los Alamos Reservoir in nearby Los Alamos Canyon. This station is equipped with a data logger with cellular telemetry and concrete control. From October 1994 through September 1995, flow was only recorded on 5 dates, with a total flow of 2.51 ft³/sec (Shaull et al. 1996).

The State of New Mexico establishes water standards to sustain and protect existing or attainable uses of water in the State. The most recent *State of New Mexico Standards for Interstate and Intrastate Streams* (State of New Mexico 1995) published by the Water Quality Control Commission states, "These general standards apply at all times, unless a specified standard is provided elsewhere in this document, to all surface waters of the State."

The specific standards that apply to waters originating within and/or flowing through LANL property have not yet been fully resolved. The standards of "wildlife habitat" and "livestock watering" apply unless it can be demonstrated that these uses are inappropriate. The appropriateness of other uses, such as "fishery use," is currently under study. At present, the designated use of LANL streams segments, including Sandia Canyon, is "wildlife habitat."

Outfall 03A113 carries blowdown discharges from 3 or 4 TA-53 cooling towers. The NPDES monitoring team estimates a typical discharge rate of 0.5–2.0 gal/min when the towers are not actively draining. If LEDA discharges release sufficient water to allow aquatic sampling in the lower outfall drainage, the Biology Team will monitor physical-chemical parameters of conductivity, water temperature, dissolved oxygen, and pH to document compliance with the criteria for wildlife habitat. These measurements will be taken concurrently with aquatic invertebrate collection.

4.2 NPDES Sampling

A water quality team from ESH-18 samples Outfall 03A113 quarterly as required by NPDES regulations. In 1996, measurements of pH, total suspended solids, chlorine,

phosphorus, and arsenic were taken at the outfall's point of discharge in February, May, August, and November. NPDES regulations require that Outfall 03A113 effluent pH be kept within 6–9 standard units and that other monitored constituents not exceed predetermined daily average and daily maximum values (Table 3). None of the monitored components exceeded the NPDES maximum allowable limits during 1996.

Table 3. NPDES Maximums for Outfall 03A113.

Effluent Constituent	Maximum Allowable Daily Average (mg/l)	Allowable Daily Maximum
Total suspended solids	30	100
Phosphorus	20	40
Arsenic	0.04	0.04
Chlorine	0.2	0.5

All 1997 measurements fell within acceptable ranges with one exception. In February, the NPDES sampling team measured 2.47 mg/l chlorine in the blowdown water at Outfall 03A113. Once the team observes a parameter exceedance, they are required to monitor the effluent until the problem has been corrected and the measurements again fall within the compliance range. Additional measurements yielded a daily average of 0.6 mg/l chlorine.

A mesh bag of chlorine tablets weighing approximately 4.5 kg (10 lbs.) is used to disinfect the blowdown effluent. The bag had been kept in a sunken compartment within a cooling tower to promote slow dissolution of the tablets. The inspection plate for this compartment had been repeatedly removed and became difficult to seal. On 18 February 1997, the chlorine bag was moved to a new location in a feeder line, whose concentrated flow greatly accelerated dissolution of the chlorine tablets. The NPDES sampling team measured the chlorine exceedance on 20 February, and the blowdown was turned off. The

problem of rapid dissolution within the feeder line was corrected, and subsequent chlorine measurements were below the compliance limit.

V. VEGETATION

5.1 Vegetation of New Mexico

Located in a semiarid environment, New Mexico is characterized by plant communities ranging from Chihuahuan desert scrub to alpine tundra (Brown 1980). North-central New Mexico contains a variety of vegetative complexes that are directly influenced by the wide range of elevational zones. Upland (nonriparian) mountainous areas contain two climatic zones consisting of three plant communities: the Rocky Mountain Subalpine Conifer Forest and Woodland, the Rocky Mountain Montane Conifer Forest, and the Great Basin Conifer Woodland (Brown 1980). Lower elevations encompass two grassland climatic zones, which contain at least three different upland communities: the Plains Grassland, the Great Basin Shrub Grassland, and the Rocky Mountain Montane Grassland.

In addition to the upland communities, numerous wetland (riparian) plant communities occur in association with most of the previously mentioned uplands. Due to the large number of wetland communities, a more general description of the climatic zones in which these communities are located is given. These wetland communities are located within five different climatic zones and include the Cold Temperate Swamp and Riparian Forest, the Arctic-Boreal Swamp-Scrub, the Arctic-Boreal Marshland, the Arctic-Boreal Strand (streams, lakes), and the Cold Temperate Strand (streams, lakes).

5.2 Vegetation of LANL

The Rio Grande floodplain contains the lowest elevations in or near Los Alamos

County and is characterized by a Plains and Great Basin Riparian-Deciduous Forest with cottonwood (*Populus* spp.) and willow (*Salix* spp.) within its boundaries. Salt cedar (*Tamarix pentandra*) and Russian olive (*Elaeagnus angustifolia*), both introduced species, are also present. Juniper and piñon pine are the typical upland overstory species at elevations ranging from about 1,705–1,890 m (5,600–6,200 ft). Both of these species are typical of the Great Basin Conifer Woodland; and both are also common at higher elevations (1,890–2,105 m or 6,200–6,900 ft) where they occupy large areas on the mesa tops. In the western portion of Los Alamos County, the woodland community intergrades with species of the Rocky Mountain Montane Conifer Forest. Ponderosa pine is a common species at about 2,105–2,285 m (6,900–7,500 ft) on the higher mesa tops and along many of the north-facing canyon slopes. White fir also occurs along the higher north-facing slopes intermixing with ponderosa pine in a mixed-conifer community. Species of the Rocky Mountain Subalpine Conifer Forest and Woodland occur along the extreme western edge of the county and are more prevalent at the higher elevations of the nearby Jemez Mountains.

Most of the streams within Los Alamos County are ephemeral (flowing during precipitation and runoff events). However, permanent flow from springs and LANL facility discharges create a small number of perennial or near-perennial stream flows within short stretches of certain canyons. Many of these streams and other wetlands are characterized by vegetation of the Rocky Mountain Riparian Deciduous Forest and the Plains Interior Marshland.

5.3 Vegetation Surveys within the Project Area

The Biology Team conducted vegetation surveys within meadows in the lower

outfall drainage area and in mid-Sandia Canyon, where LEDA discharges may ultimately flow. All transects were laid out perpendicular to established drainages located roughly in the middle of the meadows. We surveyed these areas in September 1996 and August 1997 to establish baseline conditions prior to the release of LEDA effluent discharges. Transects were established in approximately the same locations during both years and read during the same season. Plants were identified with the aid of standard reference books, including Martin and Hutchins (1980), Allred (1993), Ivey (1995), Hitchcock and Chase (1971), and Foxx and Hoard (1995). Questionable identifications were confirmed at the University of New Mexico herbarium.

Transects 1 and 2 occur in a low meadow to the north of East Jemez Road. The soil appears to have been scraped off many years ago, possibly for road construction. Two large ponderosa pines grow in a relatively undisturbed setting, and the understory plant community between them is more characteristic of natural areas. A few scattered shrub thickets of chamisa (*Chrysothamnus nauseosus*), wax currant (*Ribes cereum*), and four-wing saltbush (*Atriplex canescens*) also occur in the meadow. These transects occur in the canyon area that would be affected by LEDA discharges earliest and most dramatically and already receive some effluent discharges and precipitation run-off from the northern mesa.

Transects 3 and 4 are south of East Jemez Road and downstream from the mid-Sandia Canyon culvert. The canyon is narrow with a fairly thick growth of ponderosa pines until approximately 30 m (100 ft) upstream from the culvert, where it broadens and the trees thin out. In this more open area, the drainage forms a braided system with many

meandering and shifting channels that are usually dry. On the south side of the road, the meadow widens to 70 m (230 ft) and supports only scattered ponderosa pines, rabbitbrush (*Chrysothamnus nauseosus*), wax currant, and New Mexico locust (*Robinia neomexicana*).

Only understory transects were conducted due to the lack of overstory in the meadows. The Biology Team placed the transects perpendicular to the drainage in low-gradient areas where water might tend to pool in the future. A transect line length of 46 m (150 ft) was chosen because that distance nearly spans the width of the meadow at transects 1 and 2. Percent cover of herbaceous plants, moss, bare soil, rock, and litter were measured with 20- × 50-cm (7.9- × 19.7-in.) plots, which were established every 3 m (10 ft) along the transect line (Daubenmire 1959). Moss (a group of non-vascular plants in the phylum Bryophyta) was analyzed with the herbaceous plants because it provides similar soil protection and vegetative cover. All species found in the 1996 and 1997 vegetation surveys are listed in Appendix A.

The vegetation data were analyzed by cover, relative plant cover, frequency, and relative frequency. The importance index is a measure of species dominance within the area. An importance index was calculated for each plant species in each transect by averaging its relative plant cover and relative frequency. Tables in sections 5.3.1 and 5.3.2 list the primary understory species (any having any importance index greater than or equal to 5.00) found within each transect.

5.3.1 1996 Vegetation Survey Results. In 1996, transect 1 had a total plant cover of 39.4% (Table 4). This was the highest plant cover recorded in the 1996 transects and is

attributable the relative lack of surface sands and gravels that inhibit plant growth.

Occasional flows in the LEDA drainage channel carry effluent and precipitation runoff from the upper mesa, which nourish plant growth in the relatively dry meadow. A 2.4-m (8-ft) -wide swathe of alluvial sediments marked the drainage in this transect, although eroded sediments were noted alongside the drainage for an additional 4.3 m (14 ft). A total of 18 species of plants was recorded within the transect, including 7 grasses.

Table 4. Dominant Understory Plants in Transects 1 and 2, 1996.

Transect	Scientific name (Common name)	Relative plant cover	Relative frequency	Importance Index
1	<i>Bouteloua gracilis</i> (blue grama)	25.30	12.96	19.13
1	<i>Bromus inermis</i> (smooth brome)	17.71	11.11	14.41
1	<i>Artemisia dracunculus</i> (false tarragon)	8.43	11.11	9.77
1	<i>Bromus frondosus</i> (weeping brome)	11.80	3.70	7.75
1	<i>Verbascum thapsus</i> (mullein)	6.75	7.41	7.08
1	<i>Elymus trachycaulus</i> (slender wheatgrass)	4.22	7.41	5.81
1	<i>Xanthium strumarium</i> (cocklebur)	3.37	7.41	5.39
1	<i>Erograstis mexicana</i> (Mexican lovegrass)	6.75	3.70	5.22
2	<i>Bouteloua gracilis</i> (blue grama)	25.23	21.05	23.14
2	<i>Artemisia dracunculus</i> (false tarragon)	24.08	18.42	21.25
2	<i>Verbascum thapsus</i> (mullein)	6.88	10.53	8.70
2	<i>Erograstis mexicana</i> (Mexican lovegrass)	6.88	10.53	8.70
2	<i>Sporobolus cryptandrus</i> (sand dropseed)	12.61	5.26	8.04
2	<i>Viguiera multiflora</i> (goldeneye)	2.52	7.89	5.21

Transect 2 had a total plant cover of 29.0% in 1996. The drainage had no defined channel, but loose sediments deposited by flowing water were noted for a distance of 10 m (34 ft) across the transect line. Transect 2 contained 13 plant species, including 6 grasses.

In 1996, transect 3 had a total plant cover of only 15.4% (Table 5), due to the extensive sand deposits carried downstream by flowing water from upper-Sandia Canyon. The main drainage occupied 9 m (30 ft) of the transect, but side drainage and sediment deposits extended for an additional 13 m (42 ft). The Biology Team recorded 17 plant species within transect 3, including 5 grasses.

Table 5. Dominant Understory Plants in Transects 3 and 4, 1996.

Transect	Scientific name (Common name)	Relative plant cover	Relative frequency	Importance Index
3	<i>Artemisia dracunculus</i> (false tarragon)	34.58	10.34	22.46
3	<i>Artemisia carruthii</i> (wormwood)	23.05	13.79	18.42
3	<i>Sporobolus cryptandrus</i> (sand dropseed)	10.09	13.79	11.94
3	<i>Erograstis mexicana</i> (Mexican lovegrass)	5.76	10.74	8.05
3	<i>Chenopodium album</i> (lamb's quarters)	4.32	6.90	5.61
4	<i>Artemisia dracunculus</i> (false tarragon)	44.12	25.00	34.56
4	<i>Sporobolus cryptandrus</i> (sand dropseed)	11.34	16.67	34.56
4	<i>Bouteloua gracilis</i> (blue grama)	8.40	8.33	8.37
4	<i>Portulaca oleracea</i> (common purslane)	12.61	4.17	8.39

Transect 4 had a total plant cover of only 15.8%, due to sand deposits from the upper canyon. In 1996, transects 3 and 4 had the lowest plant cover values recorded in the study. The main drainage cut across 10.5 m (34.5 ft) of the transect, and other deposits

undoubtedly limited plant growth. Transect 4 contained 15 plant species, including 5 grasses.

In 1996, a total of 29 plant species, including 9 grasses, were found in the 4 vegetation transects. Plant cover averaged only 24.9% due to extensive deposits of sand and other erodible materials transported from upstream areas. The average cover value of transects 1 and 2 (34.2%) was higher than that of transects 3 and 4 (15.6%) because their side-canyon has received significantly less sedimentary deposits.

In terms of relative cover and relative frequency, the most abundant plant species in the transects were herbaceous sagebrushes (*Artemisia* spp.), sand dropseed (*Sporobolus cryptandrus*), and blue grama (*Bouteloua gracilis*). These three taxa account for 61.1% of the combined importance indices for all 1996 transects.

5.3.2 1997 Vegetation Survey Results. In 1997, transect 1 had a total plant cover of 52.9% (Table 6), the highest recorded in either year. This comparatively lush growth is due in large part to a wet spring and frequent summer rains with sharply contrasted with a severe drought during the early spring of 1996. The drainage channel occupied only 3.7 m (12 ft) of the transect, so that only one Daubenmire reading was taken in this relatively bare area. Transect 1 contained 18 plants, including 6 grasses.

Transect 2 had a total plant cover of 45.0% in 1997. The poorly defined drainage extended for about 6 m (20 ft) across the transect. Transect 2 contained total of 17 plant species, including 7 grasses species.

Table 6. Dominant Understory Plants in Transects 1 and 2, 1997.

Transect	Scientific name (Common name)	Relative plant cover	Relative frequency	Importance Index
1	<i>Verbascum thapsus</i> (mullein)	29.52	16.22	22.87
1	<i>Artemisia dracunculus</i> (false tarragon)	20.10	13.51	16.81
1	<i>Bromus inermis</i> (smooth brome)	6.91	9.46	8.18
1	<i>Erograstis mexicana</i> (Mexican lovegrass)	7.04	6.76	6.90
1	<i>Conyza canadensis</i> (horseweed)	6.41	6.76	6.58
1	<i>Elymus trachycaulus</i> (slender wheatgrass)	2.51	8.11	5.31
1	<i>Bromus frondosus</i> (weeping brome)	4.65	5.41	5.03
1	<i>Sporobolus cryptandrus</i> (sand dropseed)	3.27	6.76	5.01
2	<i>Bouteloua gracilis</i> (blue grama)	28.06	15.15	21.61
2	<i>Erograstis mexicana</i> (Mexican lovegrass)	20.68	9.09	14.89
2	<i>Bromus frondosus</i> (weeping brome)	11.96	15.15	15.56
2	<i>Verbascum thapsus</i> (mullein)	8.86	9.09	8.98
2	<i>Artemisia carruthii</i> (wormwood)	7.39	6.06	6.72
2	<i>Festuca pratensis</i> (meadow fescue)	6.79	6.06	6.43
2	<i>Mentzelia pumila</i> (stickleaf)	2.95	7.58	5.26

Transect 4 had a total plant cover of 25.8% in 1997. The damp drainage channel extended for 10.5 m (35 ft) through the transect, but the vegetation was comparatively lush along the transect's south end. Transect 4 contained 16 plant species, including 5 grasses.

Table 7. Dominant Understory Plants in Transects 3 and 4, 1997.

Transect	Scientific name (Common name)	Relative plant cover	Relative frequency	Importance Index
3	<i>Bryophyta</i> (moss)	17.78	11.11	14.45
3	<i>Artemisia dracunculus</i> (false tarragon)	15.69	11.11	13.40
3	<i>Bromus frondosus</i> (weeping brome)	6.90	16.67	11.79
3	<i>Sporobolus cryptandrus</i> (sand dropseed)	7.32	9.26	8.29
3	<i>Bouteloua gracilis</i> (blue grama)	12.55	3.70	8.13
3	<i>Verbascum thapsus</i> (mullein)	7.32	5.56	6.44
3	<i>Artemisia carruthii</i> (wormwood)	8.37	3.70	6.04
3	<i>Erograstis mexicana</i> (Mexican lovegrass)	6.28	5.56	5.92
3	<i>Artemisia frigida</i> (estafiata)	5.23	5.56	5.39
4	<i>Artemisia dracunculus</i> (false tarragon)	36.08	12.77	24.42
4	<i>Viguiera multiflora</i> (golden-eye)	18.04	10.64	14.34
4	<i>Sporobolus cryptandrus</i> (sand dropseed)	11.86	14.89	13.37
4	<i>Pectis angustifolia</i> (fetid-marigold)	9.02	6.38	7.70
4	<i>Bouteloua gracilis</i> (blue grama)	7.73	6.38	7.06
4	<i>Bryophyta</i> (moss)	3.87	8.51	6.19

In 1997, a total of 31 plant species, including 9 grasses, were found in the 4 transects. Plant cover averaged 38.9%, a marked increase from 1996. The average cover of transects 1 and 2 (49.0%) was higher than that of transects 3 and 4 (28.8%), the same pattern observed in 1996.

In terms of 1997 relative cover and relative frequency, the most abundant plants were herbaceous sagebrushes (*Artemisia* spp.), blue grama (*Bouteloua gracilis*), mullein (*Verbascum thapsus*), and weeping brome (*Bromus frondosus*). These four taxa account for 53.0 % of the importance indices for all transects.

5.3.3 Combined Vegetation Survey Results. The effect of greater precipitation during the 1997 growing season was shown by the occurrence of moss in 100% of its transects and meadow fescue in 75% of its transects whereas neither was found in any of the 1996 transects. Each of the 1997 transects also had a higher plant cover than its 1996 counterpart. The 1997 average plant cover (38.9%) was 156% higher than in 1996 (24.9%). This comparatively lush growth is due in large part to a wet spring and frequent summer rains during 1997's growing season. In contrast, the spring of 1996 experienced the most severe soil drought ever recorded in northern New Mexico. In both years, transects 1 and 2 had more plant cover than transects 3 and 4 due to increased moisture from the northern mesa and smaller bare areas in their drainage channel.

Taxa compositions in the transects were similar with 5-7 grasses and 7-11 non-grass species present. The most dominant plants (false tarragon, blue grama, weeping brome, Mexican lovegrass, sand dropseed, and mullein) occurred in most transects during both years (see Appendix A). Despite variations in soil, moisture, and competition within and between transects, overall habitat differences were slight. All herbaceous plants in the transects were upland species, which indicates the ephemeral nature of flows in mid-Sandia Canyon and the LEDA drainage.

Many of the plants (false tarragon, verbascum, sand dropseed, and wormwood) found in high numbers within the transects are associated with disturbed areas. Their

dominance indicates a high level of previous disturbance in mid-Sandia Canyon; and the area has never recovered from scraping for the construction of East Jemez Road. Seasonal flooding in the canyon also contributes to soil instability, but does not supply sufficient water to permit the development of a more established plant community.

VI. WILDLIFE

6.1 Wildlife of LANL

In Los Alamos County, the wide range of plant communities contain a correspondingly wide range of micro- and macro-habitats. This diversity of habitats results in a relatively wide diversity of wildlife species, including both invertebrates and vertebrates.

6.1.1 Invertebrates. Surveys for terrestrial and aquatic invertebrates have been conducted on the Laboratory and Bandelier National Monument. However, the results from these surveys are restricted to localized areas and are limited in regional application. Members of the Biology Team have found 4 genera of aquatic mollusks and 15 genera of terrestrial mollusks on LANL property. Researchers have found 193 genera of aquatic insects and 20 other aquatic non-insect invertebrate taxa in the waterways on and adjacent to LANL property. At least 89 families of terrestrial insects and 45 families of terrestrial non-insect arthropods have been identified on the Laboratory property.

6.1.2 Fish. Due to the primarily ephemeral nature of the waterways, no fish have been found on Laboratory property. Fish have been observed in nearby Guaje Canyon, Los Alamos Canyon, and at the confluence of White Rock Canyon and the Rio Grande. A

current USFWS study will determine if fish can survive within LANL canyons, including upper Sandia Canyon.

6.1.3 Reptiles and Amphibians. A variety of reptiles are common throughout much of the County and include at least 14 species of skinks, lizards, and snakes. The presence of wetlands adds additional habitat for water-associated species. At least seven species of amphibians are found in the County.

6.1.4 Birds. Birds are the most diverse group of wildlife occurring in the area, due in part to the wide range of available habitats. This group includes a variety of nesting and migrating raptors that occupy some of the relatively undisturbed areas and the steeper canyon walls. The more than 200 bird species that have been recorded in Los Alamos County include at least 112 species of breeding birds (Travis 1992), most of them migratory summer residents.

6.1.5 Mammals. At least 29 species of small mammals occur in the area, some of which are specific to defined elevational ranges. Deer mice (*Peromyscus maniculatus*), woodrats (*Neotoma mexicana*), and least chipmunks (*Eutamias minimus*) inhabit most areas of the region. Piñon mice (*Peromyscus trueii*) are found primarily in piñon-juniper woodlands; western red-backed voles (*Clethrionomys californicus*) occur in the higher elevations; while western harvest mice (*Reithrodontomys megalotis*) and long-tailed voles (*Microtus longicaudus*) are found in moist canyon bottoms. Shrews (*Sorex palustris* and *S. vagrans*) live near flowing water. Thirteen species of bats (order Chiroptera) have been recorded within LANL boundaries.

The most commonly seen large mammals in Los Alamos County are mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus nelsonii*). These species generally winter in the lower elevations of the Pajarito Plateau and spend their summers at the higher elevations of the Jemez Mountains. However, recent surveys in the Los Alamos County area indicate that expanding populations of these species reside year-round at lower elevations. Little population data is available for the other large- and medium-size mammals of the area. The County supports at least 12 species of mammalian carnivores, including mountain lion (*Felix concolor*), bobcat (*Lynx rufus*), fox (*Vulpes fulva*), and coyote (*Canis latrans*).

6.2 Wildlife of the Project Area

The Biology Team selected several groups of animals to monitor the effects of LEDA discharges on local wildlife. The studies were conducted to provide baseline data documenting conditions in mid-Sandia Canyon prior to LEDA releases. An increase in available drinking water is expected to increase bird diversity and abundance, and the Biology Team conducted bird surveys along the lower drainage in August 1996 and September 1997. We monitored reptile and amphibian populations daily for a 2-month period in the late summer of 1996 and for a 4-month period through the spring and summer of 1997. In the future, these studies may be supplemented by monitoring large mammal movements within the canyon. If LEDA discharges significant quantities of effluent to produce ponding, the Biology Team may initiate aquatic invertebrate studies within areas of standing and/or flowing water.

6.2.1 Birds. David Keller, an experienced ornithologist on the Biologist Team, systematically walked mid-Sandia Canyon to determine its resident summer bird populations. Surveys include 15 observation points with approximately 200 meters between adjacent points. Surveys begin soon after daybreak and end before 11 AM, usually the best time for recording maximum numbers of bird species and individuals. Observations consists of 6 minutes spent at each point, during which all species heard and/or seen are recorded. Each observation includes the individual's species and estimated distance from the observation point. Habitat type and meteorological information are also recorded at all observation points. Unknown birds are identified with a published guide in the field (National Geographic Society 1987) or on return to the lab (Ehrlich et al. 1988 and Travis 1992).

David Keller conducted a bird survey within the LEDA lower outfall drainage and in mid-Sandia Canyon on 14 August 1996. He found a total of 109 individuals of 25 bird species (Appendix B), the most common being pygmy nuthatches (*Sitta pygmaea*), American robins (*Turdus migratorius*), lesser goldfinches (*Carduelis psaltria*), chipping sparrows (*Spizella passerina*), mountain chickadees (*Parus gambeli*), and spotted towhees (*Pipilo erythrophthalmus*). Keller conducted another bird survey in the same area on 12 September 1997. He found 111 birds of 21 species, the most common being bushtits (*Psaltiriparus minimus*), pygmy nuthatches (*Sitta pygmaea*), chipping sparrows (*Spizella passerina*), lesser goldfinches (*Carduelis psaltria*) and Virginia's warblers (*Vermivora virginiae*). These results are typical of bird populations in local dry canyons that are

disturbed by frequent road noise. No waterbirds or birds associated with wetlands were found in either survey.

6.2.2 Reptiles and Amphibians. Reptiles and amphibians are captured in pitfall traps, containers dug into the ground so that the top is flush with the ground surface (Heyer 1994). Animals stumble into the traps and cannot climb out the vertical sides. Drift fences are metallic obstructions placed to intercept the animals and to direct them towards the pitfall traps. A pitfall array consists of 4 traps placed along a drift fence, one trap on each side at each end of the fence.

We recorded the species name, mass, total length, tail length, and tail regrowth rate (where applicable) for all captured amphibians and reptiles. A Mitutoyo Scale measured snout-vent length and vent-tail tip length, and a Mettler Scale measured the animal's mass. Larger individuals were implanted with a passive integrated transponder (PIT) containing a unique code for recapture identification (Camper and Dixon 1988; Schooley and Van Horne unpublished). PIT tags are small capsules containing microchips that are injected into the abdominal cavity. Tags are activated by a portable reader and are a relatively harmless method of mark-recapture. All captured individuals were returned to their place of capture within 24 hours.

In 1996, the Biology Team constructed 8 pitfall arrays in mid-Sandia Canyon, 4 along each side of East Jemez Road. Each array consisted of 4 1-gallon buckets and a 30-cm (12 in.)-high and 5-m (16 ft)-long drift fence. Arrays were placed within and near to the future LEDA drainage and spaced at least 20 m (65 ft) apart. Pitfall traps were opened on Monday, checked Tuesday through Friday, and closed on Friday.

In 1996, the trapping season in mid-Sandia Canyon ran from 26 July–30 September. During that period, 32 individuals of 4 species were captured (Table 8). The most common animals captured were Eastern fence lizards and many-lined skinks. We caught only 1 amphibian, a tiger salamander (*Ambystoma tigrinum*) captured near the end of the trapping season.

Table 8. Reptiles and Amphibians Captured in middle Sandia Canyon during 1996.

Common Name	Scientific Name	Number of Individuals	Relative Abundance
Eastern fence lizard	<i>Sceloporus undulatus</i>	18	56.2%
Many-lined skink	<i>Eumeces multivirgatus</i>	7	21.9%
Plateau striped whiptail	<i>Cnemidophorus velox</i>	6	18.8%
Tiger salamander	<i>Ambystoma tigrinum</i>	1	3.1%

In 1997, the Biology Team modified the pitfall traps to ensure more reliable data collection. All pitfall containers were replaced with 5-gallon buckets to minimize the possibility of escape. The number of trap arrays was reduced from 8 to 4, so that 16 rather than 32 traps were monitored. This consolidation conserved limited project resources by permitting more rapid field checks.

Some captured animals were individually marked with PIT tags as in 1996 or by toe clipping, which was used in animals weighing less than 8 grams (0.28 oz.). Toes are clipped in unique combinations to give each animal an individual marking. These methods show if an animal had been previously caught. Information from recaptured animals allows assessments of the animals' health, home range, and habitat preferences.

In 1997, the mid-Sandia Canyon trapping season ran from 8 May–18 September. In that period, 56 individuals of 5 species were captured (Table 9), including one western terrestrial garter snake that was caught by hand near a pitfall trap. The other 4 species

were the same as those captured in 1996, although the relative abundances changed markedly. During the 1997 trapping season, 33 animals were toe-clipped, and 3 of these animals were recaptured. During 1996 and 1997, a total of 7 whiptails were injected with PIT tags, but none of the injected animals were recaptured. As in 1996, we captured only 1 amphibian, a tiger salamander (*Ambystoma tigrinum*) caught near the end of the trapping season.

Table 9. Reptiles and Amphibians Captured in middle Sandia Canyon during 1997.

Common Name	Scientific Name	Number of Individuals	Relative Abundance
Eastern fence lizard	<i>Sceloporus undulatus</i>	19	32.8%
Many-lined skink	<i>Eumeces multivirgatus</i>	15	25.9%
Plateau striped whiptail	<i>Cnemidophorus velox</i>	22	37.9%
Tiger salamander	<i>Ambystoma tigrinum</i>	1	1.7%
Western terrestrial garter snake	<i>Thamnophis elegans</i>	1	1.7%

The increase in captured animals (58 in 1997 as compared to 32 in 1996) is probably due to increased precipitation, a longer trapping season, and larger traps that reduced escapes. In 1997, the most commonly captured animals were the Plateau striped whiptail, the Eastern fence lizard, and the many-lined skink. The increase in total number and relative abundance of whiptail lizards is attributed primarily to the larger pitfall traps. Other changes, such as a noticeable relative decrease in Eastern fence lizards (56.2% to 32.8%), may be due to annual variation. A 2-year comparison of trap sites shows that microhabitat preferences do not explain such a large difference in relative abundances. The reptiles and amphibians captured during 1996 and 1997 are characteristic of dry canyons in the area that have infrequent flow regimes.

The Biology Team hopes to continue its reptile and amphibian study in this area during 1998. If necessary funding is secured, microhabitat parameters will be measured, monitored, and assessed. If LEDA operations add significant quantities of water to Outfall 03A113, we would expect a dramatic increase in the numbers and relative abundances of amphibians, including tiger salamanders, chorus frogs (*Pseudacris triseriata*), Woodhouse toads (*Bufo woodhousei*), and western spade-foot toads (*Scaphiopus multiplicata*).

6.2.3 Large Mammals. In 1948, the New Mexico Game and Fish Department released 28 Rocky Mountain elk into the Jemez Mountains. This initial population has dramatically increased to an estimated 6,000–8,000 head (Gonzales et al. 1995). Many elk remain on LANL property throughout the year, and elk calves have been observed in Sandia Canyon, Cañada del Buey, and Pajarito Canyon. Increases in both elk and mule deer herds are believed to result from a lack of hunting pressure and the expansion of suitable foraging habitat following the 1977 La Mesa Fire.

Between January 1990 and February 1995, police reports documented 105 accidents in Los Alamos County due to vehicular collisions with mule deer (54) and elk (51) (Gonzales et al. 1995). During that period, the section of East Jemez Road from State Route 4 to Diamond Drive has experienced vehicular accidents with 3 elk, 1 deer, and 1 coyote. Throughout the County, the greatest numbers of these collisions occurred during fall and from 4:00 PM–12:00 AM. Increased water in mid-Sandia Canyon from LEDA discharges should increase habitat attractiveness to both deer and elk.

VII. THREATENED AND ENDANGERED SPECIES

The USFWS lists 7 T&E animals and no T&E plants as occurring in or potentially

occurring in Los Alamos County. Potential occurrences are based on preferred habitats of the species and the presence of those habitats within or near Los Alamos County. Table 10 lists all T&E species occurring or potentially occurring in the County along with their listing status and preferred habitat. In addition to these officially listed species, 12 other species of concern occur or potentially occur in Los Alamos County. These species are monitored by the USFWS and may be listed in the future.

The primary impact of the LEDA project on the surrounding environment will probably be habitat improvement due to the addition of noncontaminated water to a typically dry section of Sandia Canyon. This may make the area more attractive to the following species:

peregrine falcon (*Falco peregrinus*) – raptor, endangered species,
ferruginous hawk (*Buteo regalis*) – raptor, species of concern,
loggerhead shrike (*Lanius ludovicianus*) – raptor, species of concern,
northern goshawk (*Accipiter gentilis*) – raptor, species of concern,
spotted bat (*Euderma maculatum*) – bat, species of concern,
big free-tailed bat (*Nyctinomops macrotis*) – bat, species of concern,
long-legged myotis (*Myotis volans*) – bat, species of concern, and
occult little brown bat (*Myotis lucifugus occultus*) – bat, species of concern.

Increased water may increase the number of vertebrate prey for the raptors and invertebrate prey for the bats. The tall tuff cliffs provide good raptor foraging habitat, and spotted bats may start to roost in the cliffs if water pools within the canyon. Construction activities are confined to previously disturbed areas, which are unsuitable habitat for animal species that potentially inhabit the larger surrounding area. Therefore, it has been

Table 10. USFWS T&E Species List for Los Alamos County.

Common Name	Scientific Name	Status*	Habitat Description
Black-footed ferret	<i>Mustela nigripes</i>	E	Prairies, usually in prairie dog towns.
American peregrine falcon	<i>Falco peregrinus anatum</i>	E	Ponderosa and piñon; nests in cliffs and rock outcrops on cliffs, known to breed locally.
Arctic peregrine falcon	<i>Falco peregrinus tundrius</i>	T (S/A)	Nests in Alaska and northern Canada, migrates along coasts to southern U.S. and Mexico.
Bald eagle	<i>Haliaeetus leucocephalus</i>	T	Riparian areas, wetlands, and open water for wintering and migrating eagles.
Mexican spotted owl	<i>Strix occidentalis lucida</i>	T w/CH	Mixed conifer in uneven-aged and multi-storied forests with closed canopies, mountains and canyons; known to breed locally.
Southwestern willow flycatcher	<i>Empidonax traillii extimus</i>	E w/PCH	Nesting habitat includes shrubs and trees in willow thickets, shrubby mountain meadows, and deciduous woodlands along streams, lakes, and bogs.
Whooping crane	<i>Grus americana</i>	E	Nests in Canada, winters along Rio Grande where it roosts near water.

*** Status Index**

E	=	Endangered
PE	=	Proposed endangered
T	=	Threatened
PCH	=	Proposed critical habitat
PT	=	Proposed threatened
PT w/CH	=	Proposed Threatened with critical habitat
S/A	=	Similarity of appearance

determined that the LEDA project may beneficially affect, but is not likely to adversely affect, potential foraging habitat for the raptors and bats listed above.

VIII. BIOLOGICAL BEST MANAGEMENT PRACTICES

Best management practices (bmps) addressing potential biological concerns will be written throughout the life of the project. At present, several biological bmps deserve mention:

Heavy equipment must not be used within the stream channel or floodplain. Off-road traffic is not permitted within the stream channel or floodplain without prior approval by the Biology Team. These areas are sensitive habitats and are protected Executive Order 11988, which mandates that potential effects of any federally funded action in a floodplain be evaluated. 10 CFR 1021 outlines the procedures for DOE compliance with the floodplain executive order and provides a means for public review. These regulations require that all DOE actions be assessed for impacts to floodplains and wetlands, regardless of size. Potential impacts are addressed in NEPA documentation and Federal Register notifications. Additionally, under Section 404 of the Clean Water Act, the degradation of floodplains and wetlands must be controlled by limiting the discharge of fill into them.

Care must be taken to minimize erosion of upper areas. A concrete spill pad or gabions may be eventually needed to limit deep cutting in the plunge pool located at the cliff base. ESH-18 is charged with making periodic inspections of this area and with developing appropriate erosion control measures should they become necessary.

Between January 1990 and February 1995, police reports documented 105 accidents in Los Alamos County due to vehicular collisions with mule deer (54) and elk (51). Increased water in mid-Sandia Canyon from LEDA discharges should increase habitat attractiveness to both deer and elk. If substantial numbers of large mammals move into the area, it may be necessary to post warning signs, decrease the speed limit, and/or install fencing along East Jemez Road. If the necessary funding becomes available, the Biology Team will monitor large animal movements within the lower outfall drainage.

Revegetation of the lower drainage area may become necessary to restore vegetation damaged by LEDA effluent flows and associated sedimentation. This area has never recovered from serious disturbance associated with road construction. Increasing amounts of erodible materials from the upper drainage would further compromise the ability of vegetation to hold soils in place. Biology Team botanists can develop an appropriate seed mix of native species for the area once LEDA discharges have ceased.

IX. CONCLUSIONS

The Biology Team hopes to be able to continue collecting baseline data from mid-Sandia Canyon to more fully document the biological conditions within the lower drainage and middle Sandia Canyon. Water quality testing and aquatic invertebrate sampling will be initiated if LEDA discharges sufficient amounts of water for ponding to occur. Large mammal monitoring may be initiated if standing or flowing water from LEDA becomes an attractive nuisance which endangers the safety of motorists on East Jemez Road.

This biological evaluation of the area affected by the LEDA project area seeks to establish biological baselines prior to the release of effluent discharges. Such monitoring

before, during, and after project completion was necessary to secure USFWS concurrence with the environmental and biological assessments prepared for the proposed project. The report discusses the current biota and physical characteristics of the drainage in mid-Sandia Canyon that will eventually receive the effluent discharges.

NPDES water quality monitoring at Outfall 03A113 found no exceedances of pH, chlorine, phosphorus, total suspended solids, or arsenic during 1996. A chlorine exceedance was observed at the outfall in 1997, but its cause was quickly identified and corrected. The soils in the lower outfall drainage and the main drainage in mid-Sandia Canyon are primarily composed of sand. These soils do not contain characteristics of hydric soils, such as high organic matter content in the upper layers, vertical streaking, organic pans, or oxidized rhizospheres. The periods of saturation in the lower Outfall 03A113 and mid-Sandia Canyon drainages are of too short a duration to produce hydric soils.

A total of 44 plant species, including 10 grasses, occurred in the 8 vegetation transects. All of these plants are upland species, indicating the ephemeral nature of flows within mid-Sandia Canyon. Plant cover averaged only 31.9% due to extensive deposits of sand and other erodible materials transported from upstream areas. The most abundant plant species in the transects were false tarragon, blue grama, weeping brome, Mexican lovegrass, sand dropseed, and mullein. These plants are frequently associated with disturbed areas, and their dominance indicates a high level of previous disturbance in mid-Sandia Canyon. The area has never recovered from past scraping for the construction of East Jemez Road. Seasonal flooding in the canyon also contributes to soil instability.

Bird surveys within the future LEDA drainage in mid-Sandia Canyon found a total of 220 individuals of 32 bird species, the most common being pygmy nuthatches, bushtits, chipping sparrows, mountain chickadees, and lesser goldfinches. These results are typical of local dry canyons that are disturbed by frequent road noise.

Pitfall traps captured 85 individuals of 5 reptile and 1 amphibian species. The most commonly captured animals were Eastern fence lizards, Plateau striped whiptails, and many-lined skinks. Three whiptail lizards were recaptured, providing data on the animals' health, home ranges, and habitat preferences. Two tiger salamanders were the only amphibians caught. LEDA discharges may increase the numbers and relative abundances of amphibians (such as tiger salamanders, chorus frogs, Woodhouse toads, and spadefoot toads) within mid-Sandia Canyon.

In terms of T&E species, the primary impact of the LEDA project on the surrounding environment may be habitat improvement due to the addition of non-contaminated water to a typically dry section of Sandia Canyon. This may increase the area's attractiveness to a federally protected raptor and several species of concern. Therefore, it has been determined that the LEDA project may beneficially affect, but is not likely to adversely affect, potential foraging habitat for these species.

X. ACKNOWLEDGMENTS

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manuscript, participating in necessary biological surveys, generating maps, and assisting with other tasks that allowed this report to be completed on time. Deserving of special mention are Tim Haarmann who oversaw the reptile and amphibian project, Esther Nelson who analyzed the reptile and amphibian data, David Keller who performed the bird surveys, and Hector Hinojosa who edited the manuscript.

XI. GLOSSARY OF ACRONYMS AND TECHNICAL TERMS

anaerobic – lacking free oxygen.

asl – above sea level.

Biology Team – a LANL team within ESH-20 charged with monitoring the environment.

blowdown – water discharged from cooling towers.

bmp – best management practice.

Bryophyta - a phylum containing non-vascular plants including mosses and liverworts.

CCDTL – coupled-cavity drift tube linear accelerator.

DOE – Department of Energy.

effluent – the outflow of a cooling tower, sanitary line, or other source of discharge.

EPG – Environmental Protection Group.

ESH-18 – LANL's Water Quality and Hydrology Group; a group within the Laboratory's Environment, Safety, and Health Division.

ESH-20 – LANL's Ecology Group; a group within the Laboratory's Environment, Safety, and Health Division.

FONSI – Finding of No Significant Impact.

forb – a non-woody plant that is not a grass or grasslike.

gabion – a wire basket filled with rocks and placed to prevent erosional losses.

gpm – gallons per minute.

hydric – of a wet or moist environment.

importance index – a measure of a plant species dominance in a community.

Laboratory – Los Alamos National Laboratory.

LANL – Los Alamos National Laboratory.

LEDA – Low Energy Demonstration Accelerator.

mA – milliampere.

MAP – Mitigated Action Plan.

macroinvertebrate – an invertebrate large enough to be seen without magnification.

MW – megawatt.

NEPA – National Environmental Policy Act.

NPDES – National Pollutant Discharge Elimination System.

NWI – National Wetlands Inventory.

overstory – the upper vegetation of an area, consisting of trees.

PIT – passive integrated transponder.

quadrat – a rectangular border used to define a particular area to be surveyed.

raptor – a predatory bird.

RFQ – radio-frequency quadrupole.

rhizosphere – an area surrounding a plant root, which becomes reddish in an anaerobic environment.

SAD – Safety Analysis Document.

substrate – the surface materials on a streambed or floodplain.

SWCS – Solid Waste Consolidation System.

TA – Technical Area.

T&E – threatened and endangered.

transect – a defined survey line.

tuff – rock composed of compacted volcanic ash.

understory – the lower vegetation of an area, consisting of grasses, forbs, and small shrubs.

USFWS – U.S. Fish and Wildlife Service.

XII. CITATIONS

10 CFR [Code of Federal Regulations] 1021, "Compliance with Floodplain/Wetland Environmental Review Requirements," DOE (April 1992).

Allred, K. W., A Field Guide to the Grasses of New Mexico, New Mexico State University, Las Cruces, New Mexico (1993).

Bennett, K., "Aquatic Macroinvertebrates and Water Quality Monitoring of Sandia Canyon," LANL report LA-12738 (1994).

Brown, D. E., "Biotic Communities of the American Southwest-United States and Mexico" in *Desert Plants*, Volume 4, Numbers 1-4, University of Arizona, Tucson, Arizona (1980).

Camper, J. D., J. R. Dixon, "Evaluation of a Microchip Marking System for Amphibians and Reptiles," Texas Parks and Wildlife Dept., Res. Publication 7100-159:1-22 (1988).

Cowardin, L. M., V. Carter, F. C. Glet, and E. T. LaRoe, *Classification of Wetlands and Deep Water Habitats of the United States*, U. S. Fish and Wildlife Service, Washington, D.C., Publication No. FWS/OBS-79/31 (1979).

Cross, S., "Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory," LANL report LA-12734-SR (1994).

Cross, S., "Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory, November 1993 to October 1994," LANL report LA-12971-SR (1995).

Cross, S., "Biological Assessments for the Low Energy Demonstration Accelerator, 1996," LANL report LA-UR-96-4785 (1996a).

Cross, S., "Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory, 1995," LANL report LA-UR-96-3684 (1996b).

Cross, S., "Revised Biological Assessment and Floodplain/Wetland Assessment for the Low Energy Demonstration Accelerator, Technical Area 53," LANL report LA-UR-96-332 (1996c).

Daubenmire, R., "A Canopy-coverage Method of Vegetation Analysis," *Northwestern Scientist* 33: 43 - 64 (1959).

DOE: Department of Energy, "Mitigation Action Plan for the Low Energy Demonstration Accelerator, TA-53," LANL report (April 1996).

DOE: Department of Energy, "Annual Report for the Low Energy Demonstration Accelerator Mitigation Action Plan, Calendar Year 1996," LANL report (March 1997).

EPG: Environmental Protection Group, *Environmental Surveillance at Los Alamos during 1994*, LANL report LA-13047-ENV (July 1996).

Ehrlich, P. R., D. S. Dobbins, and D. Wheye, *The Birder's Handbook*, Simon and Schuster, Inc., New York (1988).

ESH-20, "Final Environmental Assessment for the Low Energy Demonstration Accelerator, Technical Area 53 , Los Alamos National Laboratory, Los Alamos, New Mexico," (1996).

Executive Order 19988, "Floodplain Management," President Jimmy Carter, USFSW (24 May 1977).

Foxx, T. S., and D. Hoard, *Flower Plants of the Southwestern Forests*, Otowi Crossing Press, Los Alamos, New Mexico (1995).

Gonzales, T. C., T. S. Foxx, and J. Biggs, "Analysis of Animal-Related Accidents in Los Alamos County," LANL report LA-UR-95-3950 (1995).

Heyer, W. R., M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster, *Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians*, Smithsonian Institution Press, Washington, D.C. (1994).

Hitchcock, A. S., and A. Chase, *Manual of the Grasses of the United States*, 2nd ed., Dover Publications, Inc., New York (1971).

Ivey, R. D., *Flowering Plants of New Mexico*, 3rd ed., Rio Rancho Printing, Rio Rancho, New Mexico (1995).

Martin, W. C., and C. R. Hutchins, *A Flora of New Mexico*, J. Cramer, Germany (1980).

National Geographic Society, "*Field Guide to the Birds of North America*," 2nd ed., published by the National Geographic Society (1987).

Schooley, R. L., and B. Van Horne, "Passive Integrated Transponders for Marking Free-Ranging Small Mammals," Colorado State University (unpublished manuscript).

Shaull, D. A., M. R. Alexander, and R. P. Reynolds, "Surface Water Data at Los Alamos National Laboratory: 1995 Water Year," LANL report LA-13177-PR (1996).

State of New Mexico, "Standards for Interstate and Intrastate Streams," New Mexico Water Quality Control Commission, Santa Fe, New Mexico (1995)

Travis, J. R., *Atlas of the Breeding Birds of Los Alamos County, New Mexico*, Pajarito Ornithological Survey, LANL report LA-12206 (1992).

Vepraskas, M. J., "Redoximorphic Features for Identifying Aquic Conditions," North Carolina Agricultural Research Service, North Carolina State University, Raleigh, N.C., Technical Bulletin 301 (1995).

WTI: Wetlands Training Institute, Inc., *Field Guide for Wetland Delineation: 1987 Corps of Engineers Manual*, Poolesville, Md., WTI 95-3 (1995).

APPENDIX A

PLANT SPECIES FOUND WITHIN VEGETATION TRANSECTS IN MIDDLE SANDIA CANYON

Scientific name	Common name	Transect number*
<i>Ambrosia franceroides</i>	ragweed	1, 2, 3
<i>Artemisia carruthii</i>	wormwood	2, 3, 4, 6, 7
<i>Artemisia dracunculus</i>	false tarragon	1, 2, 3, 4, 5, 6, 7, 8
<i>Artemisia frigida</i>	estafiata	6, 7
<i>Artemisia ludoviciana</i>	wormwood	3, 4, 7
<i>Atriplex canescens</i>	four-wing saltbush	5
<i>Bahia dissecta</i>	wild chrysanthemum	8
<i>Bouteloua gracilis</i>	blue grama	1, 2, 3, 4, 5, 6, 7, 8
<i>Bromus frondosus</i>	weeping brome	1, 2, 4, 5, 6, 7, 8
<i>Bromus inermis</i>	smooth brome	1, 5
<i>Bromus tectorum</i>	downy chess	2
<i>Bryophyta</i>	moss	5, 6, 7, 8
<i>Cearstium arvense</i>	mouse-ear chickweed	1
<i>Chenopodium album</i>	lamb's quarters	3, 7
<i>Chrysothamnus nauseosus</i>	chamisa	3, 4
<i>Conyza canadensis</i>	horseweed	1, 5
<i>Croton texensis</i>	doveweed	6
<i>Descurania richardsonii</i>	tansy mustard	5
<i>Elymus trachycaulus</i>	slender wheatgrass	1, 2, 3, 5, 6, 7
<i>Erigeron philadelphicus</i>	common fleabane	6
<i>Eriogonum jamesii</i>	antelope sage	2, 3, 4
<i>Erograstis mexicana</i>	Mexican lovegrass	1, 2, 3, 5, 6, 7, 8
<i>Festuca pratensis</i>	meadow fescue	6, 7, 8
<i>Fragaria americana</i>	strawberry	7

Scientific name	Common name	Transect number*
<i>Helianthus petiolaris</i>	prairie sunflower	1
<i>Ipomopsis aggregata</i>	skyrocket	3
<i>Lycurus phleoides</i>	wolftail	6
<i>Melilotus officianale</i>	yellow sweet-clover	1
<i>Mentzelia pumila</i>	stickleaf	6
<i>Oenothera albicaulis</i>	prairie evening-primrose	6
<i>Panicum capillare</i>	witchgrass	4
<i>Parthenocissus inserta</i>	Virginia creeper	5
<i>Pectis angustifolia</i>	fetid-marigold	1, 4, 8
<i>Poa fendleriana</i>	muttongrass	1, 3, 4, 6
<i>Portulaca oleracea</i>	common purslane	1, 4, 8
<i>Robinia neomexican</i>	New Mexico locust	1
<i>Rubus strigosus</i>	wild raspberry	5
<i>Sisymbrium altissiumum</i>	tumble mustard	2, 4
<i>Sphaeralcea incana</i>	globe mallow	5
<i>Sporobolus cryptandrus</i>	sand dropseed	1, 2, 3, 4, 5, 7, 8
<i>Taraxacum officinale</i>	dandelion	1, 3
<i>Verbascum thapsus</i>	mullein	1, 2, 3, 5, 6, 7
<i>Viguiera multiflora</i>	goldeneye	2, 3, 4, 8
<i>Xanthium strumarium</i>	cocklebur	4, 6

* 1997 transects are numbered as followed:

5 = 1997 transect 1

6 = 1997 transect 2

7 = 1997 transect 3

8 = 1997 transect 4

APPENDIX B

BIRD SPECIES FOUND IN MIDDLE SANDIA CANYON BIRD TRANSECTS

1996

Common Name	Scientific Name	Number of Individuals	Relative abundance
American robin	<i>Turdus migratorius</i>	11	9.82%
Ash-throated flycatcher	<i>Myiarchus cinerascens</i>	5	3.57%
Black-chinned hummingbird	<i>Archilochus alexandri</i>	5	4.46%
Bell's vireo	<i>Vireo bellii</i>	1	0.89%
Blue grosbeak	<i>Guiraca caerulea</i>	3	2.68%
Canyon wren	<i>Catherpes mexicanus</i>	2	1.79%
Chipping sparrow	<i>Spizella passerina</i>	7	6.25%
Gray flycatcher	<i>Empidonax wrightii</i>	1	0.89%
House finch	<i>Carpodacus mexicanus</i>	4	3.57%
House wren	<i>Troglodytes aedon</i>	1	0.89%
Lesser goldfinch	<i>Carduelis psaltria</i>	8	7.14%
Mountain chickadee	<i>Parus gambeli</i>	7	6.25%
Northern flicker	<i>Colaptes auratus</i>	4	3.57%
Nothorn mockingbird	<i>Mimus polyglottos</i>	2	1.79%
Pygmy nuthatch	<i>Sitta pygmaea</i>	13	11.61%
Scrub jay	<i>Aphelocoma coerulescens</i>	3	2.68%
Solitary vireo	<i>Vireo solitarius</i>	1	0.89%
Spotted towhee	<i>Pipilo erithrophthalmus</i>	7	6.25%
Virginia's warbler	<i>Vermivora virginiae</i>	2	1.79%
Violet-green swallow	<i>Tahycineat thalassina</i>	4	3.57%
Western bluebird	<i>Sialia mexicana</i>	4	3.57%
Western kingbird	<i>Tyrannus verticalis</i>	4	3.57%
Western tanager	<i>Piranga ludociviana</i>	6	5.36%
Western wood-pewee	<i>Contopus sordidulus</i>	4	3.57%

1997

Common Name	Scientific Name	Number of Individuals	Relative abundance
American robin	<i>Turdus migratorius</i>	4	3.60%
Black-chinned hummingbird	<i>Archilochus alexandri</i>	1	0.90%
Bushtit	<i>Psaltiriparus minimus</i>	20	18.02%
Canyon towhee	<i>Pipilo fuscus</i>	3	2.70%
Canyon wren	<i>Catherpes mexicanus</i>	5	4.50%
Chipping sparrow	<i>Spizella passerina</i>	10	9.01%
Common raven	<i>Corvus corax</i>	5	4.50%
Dark-eyed junco	<i>Junco hyemalis</i>	5	4.50%
Gray flycatcher	<i>Empidonax wrightii</i>	1	0.90%
Lesser goldfinch	<i>Carduelis psaltria</i>	7	6.31%
Mountain chickadee	<i>Parus gambeli</i>	4	3.60%
Northern flicker	<i>Colaptes auratus</i>	7	6.31%
Pine siskin	<i>Carduelis pinus</i>	2	1.80%
Pygmy nuthatch	<i>Sitta pygmaea</i>	13	11.71%
Scrub jay	<i>Aphelocoma coerulescens</i>	5	4.50%
Spotted towhee	<i>Pipilo erthrophthalmus</i>	5	4.50%
Virginia's warbler	<i>Vermivora virginiae</i>	6	5.41%
Western bluebird	<i>Sialia mexicana</i>	2	1.80%
Western wood-pewee	<i>Contopus sordidulus</i>	2	1.80%
White-breasted nuthatch	<i>Sitta carolinensis</i>	2	1.80%
Yellow-rumped warbler	<i>Dendroica coronata</i>	2	1.80%